DEVICE FOR SCANNING A YARN WITH A LIGHT BEAM

The invention relates to a device for scanning a yarn that
is moved in its longitudinal direction in a measuring gap
5   with a light beam from a light source, which device has a
receiver for light reflected by the yarn and a unit for
processing electrical signals from the receiver.

Such a device is known, for example, from EP 0 761 585, in
10 which there is provided a light source which emits light
which on the one hand is reflected and on the other hand
is also shaded by the yarn. The light received by
receivers is converted in a manner known *per se* into
electrical signals for which ranges or threshold values
15 can be provided in order, for example, to detect foreign
bodies in the yarn.

This device has the disadvantage that, for example,
foreign bodies in the yarn that have the same colour as
20 the emitted light cannot be detected therewith. However,
the same is also true, for example, of transparent foreign
bodies such as pieces of plastics film in the yarn, so
that such foreign bodies cannot be detected with this
device.
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A further device of this type is known from WO 95/29396,
in which three different light sources are associated with
a receiver for white light. These three light sources are
in the form of three light-emitting diodes, each diode
30 emitting light of a different main wavelength in the
visible range. When viewed in the longitudinal direction
of the yarn, the light sources are arranged one behind the

other next to the yarn and are so oriented that they illuminate the yarn and a background that is located behind the yarn and absorbs as much light as possible. The signals produced in the receiver by reflection of the

5   light by the yarn are processed in such a manner that ratios are formed from the values determined for the signals in the individual main wavelengths, which ratios can in turn be measured against criteria.

10   A particular disadvantage of this device is that it is only suitable for the evaluation of reflected light with yarn in front of a preferably black background. Moreover, the arrangement of three or more diodes at intervals along the yarn requires a large amount of space, which may not

15   even be available at those locations in textile machines that are intended for such devices. This device has the additional problem that operation of the individual light sources must take into account the movement of the yarn and it must therefore be provided that the same point on

20   the yarn is always illuminated with light of a different colour.

The invention, as characterised in the patent claims, achieves the object of providing a device of the mentioned

25   type which requires little space, is more simple to operate and permits the detection of foreign bodies in the yarn more selectively and with greater sensitivity.

This is achieved according to the invention with a device

30   which provides a single light source for emitting light in at least two wavelength regions, the wavelength regions being determined by main wavelengths. The main wavelengths

determine at least two colours in the region of wavelengths of visible light. These are preferably the colours red, green or blue. The light source is preferably in the form of a light-emitting diode which is able

5 separately to emit visible light in three colours in the visible range. The light source and the receiver exhibit principal axes for the emission and reception of light which together define a plane that is transverse to the longitudinal direction of the yarn. The unit for

10 processing electrical signals from the receiver for reflected light forms a vector in a plane or in a space from the signals in each of the at least two specified wavelength regions and forms a sum vector from the vectors for the various signals. For the end point of the sum

15 vector in the space there is specified a region which indicates whether the electrical signal from the receiver processed to form the sum vector indicates a foreign body in the yarn. The space in which the vectors are calculated and/or represented preferably forms a cube with axes along

20 which values for the intensity of three main wavelengths are plotted.

The advantages achieved by the invention are that the single light source illuminates the yarn with light having

25 different wavelengths from virtually the same point, so that the light beams in all the wavelength regions strike the yarn within a narrowly limited angle. This light source does not require much space either, so that it is possible to build a measuring head for yarn that can be

30 installed at a narrowly delimited location in the spinning machine or spooler. Moreover, the mentioned light source is substantially less expensive than a group having one

light source for each colour. Because it is also possible
to provide a plurality of receivers which convey the light
reflected by the yarn to a unit for processing electrical
signals which processes these signals in exactly the same
5   manner, it is possible to scan the whole of the yarn
surface facing the receivers. The use of a plurality of
identical receivers for white light permits the detection
of the colours of the yarn without spectral errors. The
evaluation of the resulting signals, with the aim of
10 forming a sum vector from the portions of the individual
colours, makes possible the selective detection of foreign
bodies of particular colours and colour shades
corresponding to particular materials. However, it is also
possible to deliberately leave foreign bodies in the yarn,
15 by first detecting them or by specifying a region for the
end point of the sum vector so that certain foreign bodies
are not detected at all. By the targeted cleaning of the
yarn in respect of particular impurities or foreign
bodies, the performance of the production machines can be
20 substantially improved.

The invention is explained in greater detail hereinbelow
by means of an example and with reference to the
accompanying figures, in which:
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Fig. 1 shows a section through a device according to the
invention,
Fig. 2, 3 and 4 each show a diagrammatic representation of
part of the device in different phases,
30 Fig. 5 shows a diagrammatic representation of wavelength
regions,

Fig. 6 and 7 each show a diagrammatic representation of the evaluation of the measured signals,

Fig. 8 to 10 each show a representation of a target region for the evaluation, and

5   Fig. 11 and 12 each show representations of possible ways of operating the light source of the device.

Fig. 1 shows a device according to the invention, such as, for example, a measuring head for measuring yarn

10   properties or for a yarn cleaner, having a measuring gap 1 in which a yarn 2 is moved in its longitudinal direction, the longitudinal direction here being oriented approximately perpendicularly to the drawing plane. A light beam 3 is produced by a light source 4 and is

15   directed towards the yarn 2. Receivers 5 and 6 for light reflected by the surface of the yarn are provided. The light source provided is a light-emitting diode, for example a so-called RGB-LED, as produced by Nichia (viewable on the Internet at www.nichia.co.jp) of type

20   NTSM 515. However, it is also conceivable to use other light sources, for example based on a laser. A further receiver 7 can additionally be provided for light shaded by the yarn 2. The receiver(s) 5, 6, 7 is/are each connected by way of a line or a bus 8 to a unit 9 for

25   processing electrical signals from the receiver(s). The unit 9 consists of a computer with a memory, that is to say, for example, of a microprocessor of known type. The light source 4 has four connections 10 *via* which the individual wavelength regions or colours can be operated

30   individually. In this example, the single light source 4 and the receiver 6 have principal axes 11 and 12 for the emission and reception of light which together define a

plane that is transverse to the longitudinal direction of the yarn and here corresponds to the drawing plane.

Fig. 2 shows, in a simplified representation, the light source 4 with three light-emitting diodes 13, 14 and 15, and the yarn 2 with a foreign body 16 embedded therein. Relative to the principal axis 11 of the light source 4, the foreign body is located just before the principal axis, starting from a direction of movement indicated by an arrow 17. The yarn 2 with the foreign body 16 is here illuminated, for example, by red light from the diode 13, which emits light in a region 20 as delimited by lines 18 and 19.

Fig. 3 shows a representation according to Fig. 2 wherein the yarn 2 with the foreign body 16 is located approximately at the principal axis 11. The yarn 2 with the foreign body 16 is here illuminated, for example, by green light from the diode 14, which emits light in a region 21 as delimited by lines 22 and 23.

Fig. 4 shows a representation according to Fig. 2 wherein the yarn 2 with the foreign body 16 is located above the principal axis 11. The yarn 2 with the foreign body 16 is here illuminated, for example, by blue light from the diode 15, which emits light in a region 24 as delimited by lines 25 and 26.

Fig. 5 shows a representation of different wavelength regions over an axis 27, along which values for wavelengths can be plotted. Values for the intensity of a signal as a function of the wavelength can be plotted

along an axis 28. Three wavelength regions 29, 30 and 31
are recorded here by way of example by means of curves
which indicate the progression of the intensity of the
emitted light in the region of their three main

5   wavelengths 32, 33 and 34. For the sake of simplicity and
for subsequent representations, these wavelength regions
can also be represented by simple rectangles 35, 36 and
37.

10 Fig. 6 shows a plane 35 defined by axes 36 and 37. Along
these axes 36, 37, values for the intensity of in each
case one colour of the light from the light source 4
reflected by the yarn can be plotted as vectors. A sum
vector 38 can be calculated therefrom. In the plane 35,

15 regions 39, 40, 41 representing particular properties of
the yarn can be specified. Such properties may be the
nature of the base materials of which the yarn consists or
the nature of the foreign bodies occurring in the yarn.

20 Analogously to Fig. 6, which applies to light from two
different wavelength regions, Fig. 7 shows a space 42,
delimited as a cube, for the representation of vectors
which correspond to the intensity of the received signals
in three different wavelength regions. One corner 43 of

25 the space should here serve as the starting point for
vectors 44, 45, 46, each of which represents a particular
wavelength region. 47 denotes a sum vector composed of the
three vectors 44, 45 and 46. This space or cube 42 can be
divided into different regions. One such region 48 is

30 shown in Fig. 8, one region 49 is shown in Fig. 9 and one
region 50 is shown in Fig. 10. These regions 48, 49 and 50
are intended as the target region for the end point 51 of

the sum vector 47. Depending on whether the end point 51
lies in one of these regions 48, 49, 50 or not, a
particular condition for a property of the yarn, such as,
for example, the presence of a particular foreign body, is
5   or is not met. The space 42, which here is in the form of
a cube, is formed by axes 52, 53 and 54, along which
values for the intensity of three main wavelengths are
plotted.

10   Fig. 11 shows various wavelength regions, as known from
Fig. 5, in this case plotted over a time axis 55. This
gives examples of possible repeating sequences for the
emission of light by the light source 4. According to a
sequence 56, the light source 4 is to emit light of the
15   colours red, green and blue in succession. A sequence 57
indicates that, over a specified time, red-coloured light
is to be emitted with decreasing intensity and at the same
time green-coloured light is to be emitted with increasing
intensity. If three colours are used, two or three
20   sequences with in each case two colours are obtained. When
the three sequences are complete, the first sequence 57 is
begun again.

Fig. 12 shows further sequences analogous to Fig. 11. A
25   sequence 58 for three colours which overlap but together
give a specified overall intensity. A sequence 59 again
involves three colours which are designated R, G and B and
which overlap. The intensity of the signals in the three
colours is always constant or maximum.

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The mode of operation of the device is additionally to be
described hereinbelow, in so far as it is not already

evident from the above descriptive parts. In order to
detect, for example, a particular foreign body in or
another property of the yarn 2, the light source is
operated by way of the connections 10 in such a manner,
5   for example, that it emits light in only a limited
wavelength region. This light is reflected by the yarn and
thrown back to a receiver 5, 6, which receives the light
and converts it into an electrical signal which is passed
by way of the line or the bus 8 to the unit 9, which
10   stores the signal or a numerical value derived therefrom.
Immediately thereafter, the light source 4 is so operated
that it emits light in a further wavelength region etc.,
so that a further signal or a further value can finally be
stored in the unit 9. From the stored values, vectors 44,
15   45 and, optionally, 46 are formed in the computer of the
unit 9, and a sum vector 38 or 47 is finally formed
therefrom. Values that define at least one region 39, 40,
41 or 48, 49, 50 in the plane 35 or in the space 42 are
stored in the unit 9, so that it is possible, by making a
20   comparison, to determine whether the end point of the sum
vector lies in one of these regions or not. As a result of
such a comparison, a signal can then be emitted by the
unit 9 by way of a line 60, which signal indicates
whether, for example, a desired property is present, for
25   example whether a foreign body is present in the yarn or
not.

If a further receiver 7 for transmitted light is present,
that receiver may, for example, emit a further signal to
30   the unit 9 indicating the diameter of the yarn. It is thus
also possible, in a known manner, to compensate for the

effect of the diameter of the yarn on the reflected light received.

As already shown in Figures 11 and 12, there are various possible ways of operating the light source 4. If, for example, continuous transitions between two or more wavelength regions are used, as shown in sequences 57 and 58, it is then also possible to determine the vectors and the sum vector 38, 47 at different times during the sequence. The sum vector 38, 47 accordingly carries out a movement in the plane or in the space during the sequence and it is possible to determine at which times, or in which parts of the wavelength regions, the end point lies within a particular region 22. Starting from mixed light from two wavelength regions it is thus also possible to acquire information about properties of the yarn which are otherwise not obtainable.

For the separate illumination of the yarn according to a sequence 56, the cycle frequency with which the individual diodes 13, 14, 15 of the light source 4 are to be operated should be at least so great that the distance moved by a particular point, such as, for example, the location at which a foreign body 16 is embedded in the yarn 2, in a particular time is such that the point still falls within the regions 20, 21 and 24. That particular time here lasts three cycles or a multiple thereof. Because the diodes 13 to 15 are arranged extremely close to one another in the single light source 4, the time required for illumination with three wavelength regions is very short and it is accordingly readily possible to scan such a point three times while it is located in front of the light source 4.

If the colours red, green and blue are chosen as the wavelength regions, these and further colours can be recognised, in the representation according to Fig. 7, in the following arrangement in the space 42:

The intensity of the black colour should be maximum in corner 43. The intensity of the red colour should be maximum in corner 61. The intensity of the green colour should be maximum in corner 62. The intensity of the blue colour should be maximum in corner 63. The intensity of the colour magenta should be maximum in corner 64. The intensity of the colour cyan should be maximum in corner 65. The intensity of the colour yellow should be maximum in corner 66, and the intensity of the white colour should be maximum in corner 67.

It is known *per se* which formulae can be used to calculate the mentioned vectors. For the sake of completeness, an example is given here. The following applies to the length of the sum vector 47, as is known from Fig. 7 and which is here denoted V_{47}:

$$\left|V_{47}\right| = \sqrt{\left|V_{44}\right|^2 + \left|V_{45}\right|^2 + \left|V_{46}\right|^2}$$

wherein V_{44}, V_{45} and V_{46} denote the lengths of the vectors 44, 45 and 46. The direction of the sum vector is determined by known rules of trigonometry. An appropriately adapted calculation can be used for the vectors of Fig. 6.

The position of the sum vector 38, 47 can give an indication, for example, of whether a foreign body is

present, what type it is and whether it is troublesome and
must be removed or not. For example, it is possible
according to Fig. 6 to determine that, for tolerated
foreign bodies, the sum vector 38 in Fig. 6 should lie
5   only with its end point in the region 41 or even in the
region 39. In Figures 7 to 10 it could be assumed, for
example, that the end point 51 of the sum vector 47 should
lie in a region 68 delimited by an area 69 and close to
the corner 67 when no foreign body is present and the yarn
10   is white or almost white. If the end point 51 lies in the
regions 48, 49 or 50, it is assumed that the foreign body
is predominantly blue, green or red. However, such a
foreign body may nevertheless be tolerable *per se*. This
may be the case, for example, for a red foreign body when
15   the yarn is subsequently to be dyed red.